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Air

Preparation of Fine Particulate Emission Inventories

Case Studies

APTI Course 419B

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Case Study Number 4-1

Estimating PM_{10} and $PM_{2.5}$ Emissions from Locomotives

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate emissions from locomotives.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 15 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This case study involves the development of a county level locomotive inventory for Sedgwick County, Kansas. In developing this inventory only two SCCs (Line-Haul and Switchyard Operations) are included. The activity data were obtained through a survey of the two railroad companies operating in the inventory area. The purpose of this case study is to require the student to review the activity data that was collected to calculate fuel consumption, and then calculate PM_{10} and $PM_{2.5}$ emissions for both line-haul and switchyard operations.

Available Data

The types of data that were obtained from the survey included locomotive fuel consumption rates and traffic density for the large line-haul locomotives; fuel consumption rates and percentage of the total track in the inventory area for smaller line-haul locomotives; and the number of yard locomotives for switchyard locomotives. Because the railroad operated outside the county, the total annual fuel consumption represented locomotives that were operated outside of the inventory area.

The specific data provided by the railroad companies included the gross tonnage by a specific line segment of the rail as well as an estimate of the distance and miles for each of these segments. They also provided a fuel consumption index of 0.00139, which

relates gallons consumed to gross ton-mile. This estimate is assumed to apply for all line segments. This data is presented in the following table.

Line-haul Locomotive Data Provided by Railroads

Line Segment	Gross Tonnage, Million GT	Distance in Miles
1	15.0	17.0
2	8.0	15.0
3	0.0	10.5

The smaller of the two railroad companies operating in the inventory area did not have records on the gross tonnage.

The railroad company also provided an estimate of the number of switchyard locomotives that are operating in each switchyard. This particular railroad operates two switchyards and provided an estimate of how often throughout the year each yard was operating. This data is presented in the following table.

Switchyard Data Provided by Railroads

Switch Yard	Number of Switchyard Locomotives
1	1.3
2	0.5
Total	1.8

Problem

As the environmental engineer for the county, you are charged with developing PM_{10} and $PM_{2.5}$ annual emission estimates for both long haul and switchyard locomotives using the available data. Only emissions are needed for the railroad company that was able to provide data. It is suggested that you approach the problem in the following manner.

1. Are the PM emission estimation methodologies the same for long haul and switchyard locomotives?

2. What PM emission factors are applicable to locomotives?

3. What is the basis of the activity data for locomotives?

4. What is the methodology for estimating PM_{10} and $PM_{2.5}$ emissions for line haul locomotives? For switchyard locomotives?

5. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from long-haul locomotives?

6. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from switchyard locomotives?

7. Why does the railroad data on switchyards show fractions of switchyard locomotives in use in each switchyard?

8. Do emissions for each line segment and switchyard need to be calculated individually?

9. How can PM_{10} and $PM_{2.5}$ emissions be estimated for locomotives of the smaller company that was not able to provide gross tonnage data?

Notes

- Conversion factors: 453.6 grams = 1 pound
  0.002204 pounds = 1 gram

- Assume that 92% of PM_{10} emissions are $PM_{2.5}$.

- EPA uses a default value of 82,500 gallons of fuel consumed for each switchyard locomotive (based on 24 hours a day, 365 days a year).

Case Study Number 7-1

Estimating PM_{10} and $PM_{2.5}$ Emissions from Unpaved Roads

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate emissions from unpaved roads.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 15 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This case study involves developing a PM_{10} inventory for unpaved roads in a hypothetical county. The method is to develop a local PM_{10} inventory using county level data where available, and filling in the gaps with NEI default data.

Available Data

In this case study, daily vehicle miles traveled (VMT) data was provided by a local metropolitan planning organization, and VMTs were calculated using TransCAD GIS-based modeling software.

The emission factor input values for surface material silt content were obtained from samples taken on dirt roads in the county for which the inventory was conducted. Default values were used for the mean vehicle weight value and the surface material moisture content. The number of days that were exceeding the precipitation threshold of 0.01 inches was obtained from a local meteorological station. The inventory is a county level inventory with a temporal resolution of monthly.

The following table shows a summary of the data that are available for use in the case study.

Data for Unpaved Road Case Study

VMT for the Month of June	2.964 million miles
Surface Material Silt Content	7.5 percent

Problem

You have been asked by your supervisor to develop an estimate of resuspended road surface material from unpaved roads in a county for the month of June. It is suggested that you approach the problem in the following manner.

1. How is the PM emission factor for unpaved roads calculated?

2. What emissions from unpaved roads are accounted for by the emission factor?

3. What is the basis of the activity data for unpaved roads?

4. What is the methodology for estimating PM_{10} emissions from unpaved roads?

5. What is the value for the empirical constant in the emission factor equation?

6. What is the value for the default surface material moisture content?

7. How is mean vehicle weight considered in the estimation of PM emissions from unpaved roads?

8. What is your estimate for the PM_{10} emission factor for unpaved roads in the hypothetical county?

9. What is your estimate of the PM_{10} emissions from unpaved roads in the county for the month of June?

10. How would $PM_{2.5}$ emissions be estimated if this case study required that an estimate of $PM_{2.5}$ be developed?

11. How would annual PM_{10} emissions from unpaved roads be calculated?

Notes

- Assume that the mean vehicle speed for vehicles on unpaved roads is 35 mph.
- Assume that PM emissions from vehicle exhaust, brake wear, and tire wear are equal to 0.2819 lbs/VMT.
- 1 lb/VMT = 281.9 g/VMT

Case Study Number 7-2

Estimating PM_{10} and $PM_{2.5}$ Emissions from Residential Construction Activities

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate PM_{10} and $PM_{2.5}$ emissions from residential construction activities.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 15 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This hypothetical case study involves developing a PM_{10} and $PM_{2.5}$ inventory for residential construction at the county level in a PM nonattainment area. In this example, local officials provided data that represent actual housing unit starts for single unit houses, duplexes, and apartment buildings. NEI default values are used where local level data is not available.

Available Data

The following table shows a summary of the data provided by local officials that are available for use in the case study.

Data for Residential Construction Case Study

	Single Family Houses (No Basements)	Duplexes	Apartments
Housing Structure Starts (B)	251	2	44
Acres Disturbed per building (f)	0.184	0.184	0.07
Duration (m) (months)	6	6	12

In addition, the Thornthwaite Precipitation Evaporation Index for the soil in the county being inventoried is 6, and the dry silt content of the county is 40 percent.

Problem

You have been asked by your supervisor to develop an estimate of fugitive dust emissions from the residential construction activities in the past year. Furthermore, the emissions estimates need to be categorized by single-family homes, duplexes, and apartments. It is suggested that you approach the problem in the following manner.

1. What PM emission factors are applicable to residential construction activities?

2. What is the basis of the activity data for residential construction activities and how is it measured?

3. What is the methodology for estimating PM_{10} and $PM_{2.5}$ emissions from residential construction activities?

4. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the residential construction activities in the county within the past year without accounting for rule effectiveness, rule penetration, soil moisture, and silt content?

5. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the residential construction activities in the county within the past year accounting for control efficiency and rule penetration, but not for soil moisture and silt content?

6. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the residential construction activities in the county within the past year accounting for control efficiency, rule penetration, and soil moisture?

7. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the residential construction activities in the county within the past year accounting for control efficiency, rule penetration, and silt content (but not soil moisture)?

8. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the residential construction activities in the county within the past year accounting for control efficiency, rule penetration, soil moisture, and silt content?

9. Explain the significance of the adjustments that are made for soil moisture content and silt content.

Notes

- Assume that none of the houses in the inventory area include basements
- Assume a Rule Effectiveness of 100%
- Assume a Control Efficiency of 50%
- Assume a Rule Penetration of 75%
- Assume $PM_{2.5}$ is 20 percent of PM_{10}

Case Study Number 7-3

Estimating PM_{10} and $PM_{2.5}$ Emissions from Road Construction Activities

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate emissions from road construction activities.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 15 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This hypothetical case study involves developing a local inventory using available county level inventory data and filling the data gaps with the NEI default data. In this case study the county officials have provided estimates of the miles of roadway constructed in the county.

Available Data

The following table shows a summary of the data that are available for use in the case study.

Data for Road Construction Case Study

Miles of roadway constructed	12.3 miles
Duration	12 months

In addition, the Thornthwaite Precipitation Evaporation Index for the soil in the county being inventoried is 6, and the dry silt content of the county is 40 percent.

Problem

You have been asked by your supervisor to develop an estimate of fugitive dust emissions from the road construction activities in the past year. It is suggested that you approach the problem in the following manner.

1. What PM emission factors are applicable to road construction?

2. What is the basis of the activity data for road construction?

3. What is the methodology for estimating PM_{10} and $PM_{2.5}$ emissions from road construction?

4. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the road construction activities in the county within the past year without accounting for rule effectiveness, rule penetration, soil moisture, and silt content?

5. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the road construction activities in the county within the past year accounting for control efficiency and rule penetration, but not for soil moisture and silt content?

6. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the road construction activities in the county within the past year accounting for control efficiency, rule penetration, and soil moisture?

7. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the road construction activities in the county within the past year accounting for control efficiency, rule penetration, and silt content (but not soil moisture)?

8. What is your estimate of the PM_{10} and $PM_{2.5}$ emissions from the road construction activities in the county within the past year accounting for control efficiency, rule penetration, soil moisture, and silt content?

Notes

- Assume that all roads fall into the urban collectors category.
- Assume a Rule Effectiveness of 100%
- Assume a Control Efficiency of 50%
- Assume a Rule Penetration of 75%

Case Study Number 9-1

Estimating PM_{10} Emissions from Residential Wood Combustion

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate PM_{10} emissions from residential wood combustion.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 20 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This case study involves the development of a PM_{10} emissions inventory for a hypothetical county. In developing this inventory, the preferred method of using a residential wood combustion survey was employed. The purpose of this case study is to require the student to review the survey data that was collected to calculate wood consumption and then PM_{10} emissions.

The hypothetical county is classified as urban since more than 50 percent of the population is located in cities and towns. The latest Census data indicates that the county has a population of 1.3 million people living in 380,000 homes. The survey was sent to 500 homes in the county.

The hypothetical county is located in the Mid-Atlantic region and the number of heating degree days falls between 5,500 and 7,000.

Available Data

The following table shows a summary of the data that was obtained as a result of a survey that was conducted in the county.

Data Obtained From the Residential Wood Combustion Survey

Number of homes with a fireplace without an insert	110
Number of homes with a fireplace with an insert	30
Number of homes with a wood stove	40
Average number of cords of wood burned in fireplaces without an insert	1/4
Average number of cords of wood burned in fireplaces with an insert	1/4
Average number of cords of wood burned in wood stoves	1/8

The data on the number of cords of wood burned are for an average winter week. The survey also asked respondents to estimate how many weeks during the year they used their fireplaces or woodstoves as well as the amount of wood that was burned during the non-winter weeks in which they used their fireplaces and woodstoves. However, the data on the temporal usage of wood was determined to be invalid.

Problem

You have been tasked with developing an annual PM_{10} emissions inventory for residential wood combustion within a hypothetical county. It is suggested that you approach the problem in the following manner.

1. What PM_{10} emission factors are applicable to residential wood combustion?

2. What is the methodology for estimating PM_{10} emissions from residential wood combustion?

3. What is your estimate of the PM_{10} emissions from residential wood combustion in the county within the past year without accounting for rule effectiveness or rule penetration?

4. What is your estimate of the PM_{10} emissions from residential wood combustion in the county within the past year accounting for rule effectiveness and rule penetration?

5. If the residential wood combustion survey failed to collect data on the amount of wood burned, how could emissions from fireplaces without inserts be calculated?

6. How would you propose to estimate $PM_{2.5}$ emissions from residential wood combustion in the county?

Notes

- Assume that the entire county is located in the same climate zone.
- Assume different types of wood are burned with an average density of 23.9 pounds per cubic feet
- Conversion factor: 1 cord = 128 cubic feet
- PM_{10} emission factor for residential fireplaces without inserts is 23.2 pounds per ton dry wood burned.
- AP-42 PM_{10} emission factor for residential fireplaces with inserts is 30.6 pounds per ton dry wood burned.
- AP-42 PM_{10} emission factor for residential woodstoves is 34.6 pounds per ton dry wood burned.
- Assume each season is 13 weeks long.
- Assume a Rule Effectiveness of 100%
- Assume a Rule Penetration of 75%

Case Study Number 9-2

Estimating PM_{10} and $PM_{2.5}$ Emissions from Agricultural Field Burning

Exercise Objective

This exercise will test your ability to apply the methodology used to estimate emissions from agricultural field burning operations.

Directions

- Review the background information and data provided.
- Convene groups of 4-5 people.
- Answer the questions in the "Problem" section. These will guide you in your thinking to organize the data and then using it to estimate emissions.
- You will have 10 minutes to complete these tasks before the class reconvenes for discussion. Each group will be assigned specific questions and asked to present its results. Other groups will be asked if they agree or disagree with the findings.

Background

This hypothetical case study involves developing a PM_{10} and $PM_{2.5}$ inventory for burning a field of wheat stubble. The method is to develop a local PM_{10} and $PM_{2.5}$ inventory using county level data where available, and filling in the gaps with NEI default data.

Available Data

This case study involves wheat stubble burning and uses county-specific data. The activity data that was obtained are the acres of wheat burned by month. This was obtained from burn permits that are usually issued by the county fire department. Also, the fuel loading for wheat stubble was obtained from the county agricultural extension office.

The following table shows a summary of the data that are available for use in the case study.

Data for Agricultural Burning Study

Number of Acres Burned in June	1,950
Wheat Stubble Fuel Loading	1 ton/acre

Problem

You have been asked by your supervisor to develop an estimate of PM_{10} and $PM_{2.5}$ emissions from these activities during the month of June. The spatial resolution for this inventory is the county and the temporal resolution is monthly. It is suggested that you approach the problem in the following manner.

1. What is the basis of the activity data for agricultural burning?

2. What does the loading factor represent?

3. What is the methodology for estimating PM_{10} emissions from agricultural burning operations?

4. What is your estimate of the PM_{10} emissions from wheat stubble burning in the county for the month of June?

5. How would $PM_{2.5}$ emissions be estimated if this case study required that an estimate of $PM_{2.5}$ be developed?

6. How would annual PM_{10} emissions from agricultural burning be calculated?

Notes

- The emission factor for wheat stubble burning is 8.82 pounds per tons of wheat stubble burned for PM_{10}.
- The emission factor for wheat stubble burning is 8.34 pounds per tons of wheat stubble burned for $PM_{2.5}$.